CHAPTER 11

Work and Energy

ONE MARK QUESTIONS

1. Does work done depend upon the velocity of the body.

Ans :

No.

2. State the law of conservation of energy.

Ans :

It states that energy can neither be created nor destroyed. It can only change its form.

3. In a tug-of-war one team gives way to the other. What work is being done and by whom?

Ans :

The winning team does work. The work is equal to the product of the resultant force and the displacement undergone by the losing team.

4. What will cause greater change in kinetic energy of a body? Changing its mass or changing its velocity?

Ans :

Changing its velocity.

5. List two essential conditions for work to be done.

Ans :

(i) A force must act and
(ii) There should be displacement in the body.

6. When is 1 joule of work said to be done?

Ans :

When a force of 1 newton acting on a body displaces it 1m in its own direction.

7. What is the SI unit of work done and power?

Ans :

Joule and Watt.

8. What is power? What is its SI unit?

Ans :

It is defined as the rate of doing work. Its unit is watt.

9. Find the energy in kWh consumed in 10 hours by a machine of power 500 W.

Ans :

$W = P \times t$

$= 500 \times 10 = 5000$ Wh $= 5$ kWh.

10. When is work said to be done against the force of gravity?

Ans :

When a body is lifted, the work is done against the force of gravity.

11. Write an expression for the work done in lifting a body of mass 'm' through a vertical height 'h'.

Ans :

Work done W = mgh, where g is acceleration due to gravity.

12. When a book is lifted from a table, against which force work is done?

Ans :

Work is done against the force of gravity.

13. Will work be done by a man who pushes a wall?

Ans :

No.

14. What is the work done when the force acting on the body and the displacement produced in the body are at right angles to each other?

Ans :

Zero.

15. Is it possible that some force is acting on a body but still the work done is zero?

Ans :

Yes, when force acts at an angle of 90° with the displacement.

16. What is the work done on a body moving in a circular path?

Ans :

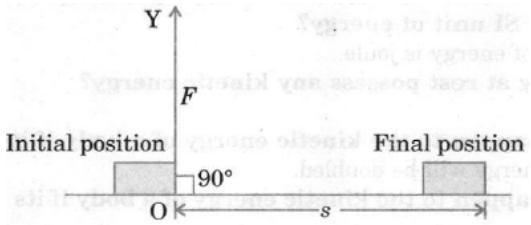
Zero, because force and displacement are perpendicular to each other.

17. Does every change in energy of the body involve work?

Ans :

Yes.

18. What is the work done in the situation shown below?



Ans :

Zero.

19. A force of 7 N acts on an object. The displacement is, say 8 m, in the direction of the force. Let us take it that the force acts on the object through the displacement. What is the work done in this case?

Ans :

Given,

$$\text{displacement} = 8 \text{ m},$$
$$\text{Force} = 7 \text{ N}$$

Now, $\text{Work done} = \text{Force} \times \text{Displacement}$

$$= 7 \times 8 = 56 \text{ J}$$

20. When do we say that work is done?

Ans :

Work is said to be done when a force causes displacement of an object in the direction of applied force.

21. Write an expression for the work done when a force is acting on an object in the direction of its displacement.

Ans :

$$\text{Work done} = \text{Force} \times \text{Displacement}$$

22. What is the kinetic energy of an object?

Ans :

The energy possessed by a body by virtue of its motion is called kinetic energy.

23. Write an expression for the kinetic energy of an object.

Ans :

The expression is $K_E = \frac{1}{2}mv^2$ where 'm' is the mass and v is the velocity of the body.

24. Define 1 watt of power.

Ans :

When a work of 1 joule is done in 1 s, the power is said to be one watt.

25. A lamp consumes 1000 J of electrical energy in 10 s. What is its power?

Ans :

Given, W = 1000 J, t = 10 s, P = ?

Using $P = \frac{W}{t} = \frac{1000}{10} = 100 \text{ W}$

26. Define average power.

Ans :

When a machine or person does different amounts of work or uses energy in different intervals of time, the ratio between the total work or energy consumed to the total time is average power.

27. Define energy.

Ans :

Energy is the ability of a body to do work. It is also defined as the capacity to do work.

28. A body performs no work. Does it imply that the body possesses no energy?

Ans :

When a body does not perform any work, it never implies that the body has no energy. The body may have energy but still does not perform any work, e.g., a book placed on a table has potential energy but is not performing any work.

29. What is the SI unit of energy?

Ans :

The SI unit of energy is joule.

30. Does a body at rest possess any kinetic energy?

Ans :

No.

31. What will happen to the kinetic energy of a body if its mass is doubled?

Ans :

Its kinetic energy will be doubled.

32. What will happen to the kinetic energy of a body if its velocity is halved?

Ans :

The kinetic energy of the body will become one-fourth.

33. By how much will the speed of a body, of fixed mass, increase if its kinetic energy becomes four times its initial kinetic energy?

Ans :

The speed is doubled.

34. Can a body possess energy even if it is not in motion?

Ans :

Yes, it can possess potential energy.

35. Define potential energy.

Ans :

It is defined as the energy possessed by a body by virtue of its position or change in shape.

36. Name the energy possessed by a stretched rubber band lying on the table.

Ans :

Potential energy.

37. Give the SI unit of potential energy.

Ans :

The SI unit of potential energy is joule.

38. What do you mean by transformation of energy?

Ans :

It is the change of energy from one form of energy into another form of energy.

39. Can energy be destroyed? Can energy be created?

Ans :

No, energy can neither be created nor be destroyed.

40. A cell converts one form of energy into another. Name the two forms.

Ans :

It converts chemical energy into electrical energy.

41. Name one unit of power bigger than watt.

Ans :

A unit bigger than watt is kilowatt.

42. When an arrow is shot from its bow, it has kinetic energy. From where does it get the kinetic energy?

Ans :

A stretched bow possesses potential energy on account of a change in its shape. To shoot an arrow; the bow is released. The potential energy of the bow is converted into the kinetic energy of the arrow.

43. Name at least three commonly used units of energy.

Ans :

(i) Joule, (ii) Erg, (iii) Kilowatt hour.

44. Name the practical unit of power in engineering.

Ans :

Horsepower.

45. Name at least six forms of energy.

Ans :

(i) Chemical energy
(ii) Heat energy
(iii) Light energy
(iv) Electrical energy
(v) Sound energy
(vi) Solar energy

46. How many watt are there in 1 horsepower?

Ans :

746 watt.

47. A light and a heavy body have equal kinetic energy. Which one is moving fast?

Ans :

The lighter body is moving fast.

48. State the relation between kWh and joule. Define 1 watt.

Ans :

$$1 \text{ kWh} - 1000 \text{ Wh} = 1000 \text{ Js}^{-1} \times 60 \times 60 \text{ s}$$
$$= 3.6 \times 10^6 \text{ J}$$

1 watt is the power of an agent which can do one joule of work in one second.

49. Can any object have mechanical energy even if its momentum is zero? Explain.

Ans :

Yes, mechanical energy comprises of both potential energy and kinetic energy. Zero momentum means that velocity is zero. Hence, there is no kinetic energy but the object may possess potential energy.

50. The potential energy of a body is 39600 J. How high is the body if its mass is 20 kg?

Ans :

The potential energy of a body = mgh

$$\text{h} = \frac{\text{P.E.}}{mg} = \frac{39600 \text{ J}}{20 \text{ kg} \times 10 \text{ m/s}^2} = 198 \text{ m}$$

51. How much work is done by a force of 10 N in moving an object through a distance of 4 m in the direction of the force?

Ans :

$$\text{Work done} = \text{Force} \times \text{Displacement}$$
$$= \text{F} \times \text{s}$$
$$= (10 \text{ N}) \times (4 \text{ m})$$
$$= 40 \text{ joule or } 40 \text{ J.}$$

52. What is power? How do you differentiate kilowatt from kilowatt hour?

Ans :

Power is the rate of doing work. Kilowatt is the unit of power and kilowatt hour is the unit of energy.

53. A rocket is moving up with a velocity v. If the velocity of this rocket is suddenly tripled, what will be the ratio of two kinetic energies?

Ans :

$$\frac{\text{Initial KE}}{\text{Final KE}} = \frac{\left(\frac{1}{2}mv^2\right)}{\left(\frac{1}{2}mv^2\right)} = \frac{\left(\frac{1}{2}mv^2\right)}{\left\{\frac{1}{2}m(3v)^2\right\}} = 1 : 9$$

54. Calculate the work done in lifting 200 kg of water through a vertical height of 6 m.

Ans :

(i) Work done in lifting a body
= Weight of body × vertical distance

(ii) The work done in lifting

$$= W = mgh$$
$$= 200 \text{ kg} \times 10 \text{ m/s}^2 \times 6 \text{ m} = 1200 \text{ J}$$

55. Give one example each of potential energy (i) due to position (ii) due to shape.

Ans :

(i) Potential energy due to position : Water stored in dam has potential energy.

(ii) Potential energy due to shape : In a toy car, the wound spring possesses potential energy and as the spring is released, its potential energy changes into kinetic energy due to which the car moves.

56. What kind of energy transformation takes place when a body is dropped from a certain height?

Ans :

When a body falls, its potential energy gradually gets converted into kinetic energy. On reaching the ground, the whole of the potential energy of the body gets converted into kinetic energy.

57. Can kinetic energy of a body be negative?

Ans :

No as mass and velocity cannot be negative

58. What is the energy of a body due to its motion called?

Ans :

Kinetic energy.

59. What is the SI unit of kinetic energy?

Ans :

Joule.

60. How does the kinetic energy of a body change if the mass of the body is halved?

Ans :

If the mass of a body is heaved the kinetic energy is also halved.

61. A car and a truck are moving with the same velocity of 60 km/hr^{-1}, which one has more kinetic energy?

Ans :

Truck has more kinetic energy as kinetic energy is directly proportional to the mass.

62. What is the relationship between watt and joules per second.

Ans :

$$1 \text{ Watt} = 1 \text{ joule/second}$$
$$1 \text{ W} = 1 \text{ Js}^{-1}$$

63. What is the relationship between kilowatt and joule per second?

Ans :

$$\text{I know} = 1000 \text{ joule/second}$$

or, $$1 \text{ kW} = 1000 \text{ Js}^{-1}$$

64. What is the relationship between kilowatt and watt?

Ans :

$$1 \text{ kilowatt} = 1000 \text{ watts}$$

or, $$1 \text{ kW} = 1000\text{W}$$

65. What is the relationship between megawatt and watt?

Ans :

$$1 \text{ megawatt} = 106 \text{ watt}$$

66. What is the relationship between megawatt and joules per second?

Ans :

$$1 \text{ megawatt} = 10^6 \text{ joule/second}$$
$$1 \text{ MW} = 10^6 \text{ js}^{-1}$$

67. What is meant by the term horsepower (hp)?

Ans :

Horsepower is another commercial unit power

$$1 \text{ hp} = 746 \text{ W}$$
$$1\text{W} = \frac{1}{746} \text{ hp} = 0.0013 \text{ hp}$$

68. What is the relationship between horse power and watt?

Ans :

$$1 \text{ horsepower} = 746 \text{ watt}$$
$$1 \text{ hp} = 746 \text{ W}$$

69. How much energy will an electric motor of 1 horsepower consume in one second?

Ans :

An electric motor will consume 746 joule of energy per second.

70. Give the mathematical relation between power, force and velocity.

Ans :

$$\text{Power (P)} = \text{force (F)} \times \text{velocity (V)}$$
$$= (\text{F} \times \text{V})$$

71. At what rate is electrical energy consumed by a bulb of 60 watt?

Ans :

A 60 watt bulb consume electrical energy at the ratio of 60 joule per second.

72. Which type of energy is present in an atom?

Ans :

Nuclear energy.

73. Which type of energy is present in a battery?

Ans :

Chemical energy.

74. Name the energy present in an object due to its position or configuration.

Ans :

Potential energy.

75. Give one example of potential energy due to position.

Ans :

Water stored in the reservoir of a dam has potential energy.

76. Give an example of potential energy due to change in shape.

Ans :

A stretched bow has potential energy due to change of shape.

77. What type of energy is possessed by a flying bird and a flying aeroplane?

Ans :

Both potential energy and kinetic energy.

78. Does the potential energy of a spring increase or decrease when it is compressed?

Ans :

The potential energy of the spring increases because work is done on it when it is compressed.

79. A spring is compressed, what change is expected in the potential energy of the spring

Ans :

When a spring is compressed, its potential energy is used up to changing its shape.

80. What is the amount of work done by a force when a body moves in a circular path?

Ans :

Work done is given by the expression $W = Fs \cos\theta$. When a body moves in a circular path, then the displacement (s) is zero. Therefore, work done is $W = F \times 0 = 0$.

81. Name the common forms of the mechanical energy.

Ans :

The common forms of the mechanical energy are :
(i) Kinetic energy
(ii) Potential energy

82. A spring which has been kept compressed by tying its ends together is allowed to be dissolved in an acid. What happens to the potential energy of the spring?

Ans :

The PE of the spring gets converted into KE of acid molecules whose temperature rises.

83. Justify giving proper reasoning whether the work done in the following case is positive or negative - Work done by resistive force of air on a vibrating pendulum in bringing it to rest.

Ans :

Work done is negative because the resistive force of air always acts opposite of the direction of motion of the vibrating pendulum.

84. The work done in lifting a box on to a platform does not depend upon how fast it is lifted up. Explain your answer giving proper reasoning.

Ans :

The work done (W) in lifting a box through a distance (s) against the gravitational force (F) is given by W = Fs. Hence, it is obvious that it is independent of the rate at which the box is lifted.

85. Is it possible that a body be in accelerated motion under a force acting on the body, yet no work is being done by the force? Explain your answer giving a suitable example.

Ans :

Yes, it is possible, when the force is perpendicular to the direction of motion. The Moon revolving round the Earth under the centripetal force of attraction of the Earth, but Earth does no work on the motion.

86. A body moves along a circular path. How much work is done in doing so? Explain.

Ans :

In case of a body moving along a circular path, the force (centripetal) is always along the radius while displacement is tangential. Hence, work done W = FS cos 90° = 0 as angle between F and S is 90°.

87. A man rowing a boat upstream is at rest with respect to the shore. Is he doing work?

Ans :

The man is doing work relative to the stream because he is applying force to produce relative motion between the boat and the stream. But he does zero work relative to the shore as the displacement relative to the shore is zero.

88. What type of energy is stored in the spring of a watch?

Ans :

When we wind a watch, the configuration of its spring is changed. The energy stored in the spring is obviously potential in nature (elastic potential energy to be more accurate).

89. When a constant force is applied to a body moving with constant acceleration, is the power of the force constant? If not, how would force have to vary with speed for the power to be constant?

Ans :

We know that,

power (p) = force (f) × velocity (v)

Since the body is moving with accleration, V changes and as a result of that P also changes, F being constant. For P to be constant, FV = constant or $F \propto \frac{1}{V}$.

Thus, as V increases, F should decrease to keep P constant.

90. A spring which is kept compressed by tying its ends together is allowed to be dissolved in an acid. What happens to the potential energy of the spring?

Ans :

The potential energy of the spring gets converted into heat energy (kinetic energy of acid molecules). Due to this heat, the temperature of the acid rises.

91. (a) How much work is done when a force of 1 N moves a body through a distance of 1 m in its direction?
(b) Is it possible that a force is acting on a body but still the work done is zero? Explain giving one example.

Ans :

(a) 1 J of work is done.
(b) Yes, it is possible when force acts at right angles to the direction of motion of the body. Example : Gravitational force of Earth acts on a satellite at right angles to its direction of motion.

THREE MARKS QUESTIONS

92. Is it possible that a body is in accelerated motion tinder a force acting on the body, yet no work is being done by the force? Explain your answer giving a suitable example.

Ans :

Yes, it is possible, when the force is perpendicular to the direction of motion. The Moon revolving round the Earth under the centripetal force of attraction of the Earth but Earth does not do any work on the motion of the Moon.

93. Define work. How is work measured? When is work done by a force negative?

Ans :

Work is said to be done if force acting on an object displaces it through a certain distance.
It is measured as the product of force and displacement.
Work done is negative if force and displacement are in the opposite direction.

94. What is the work done by the force of gravity in the following cases?
(a) Satellite moving around the Earth in a circular orbit of radius 35000 km.
(b) A stone of mass 250 g is thrown up through a height of 2.5 m.

Ans :

(a) Zero, as the displacement in one complete revolution is zero.
(b) Given m = 250 g = 0.25 kg, h = 2.5 m, g = 10 ms^{-2}, W = ?

Now, $W = Fs = mg \times h$

$= 0.25 \times 10 \times 2.5 = 6.25$ J

95. A battery lights a bulb. Describe the energy changes involved in the process.

Ans :

Within the electric cell of the battery the chemical energy changes into electrical energy. The electric energy on flowing through the filament of the bulb, first changes into heat energy and then into the light energy.

96. What kind of energy transformations take place at a thermal power station?

Ans :

At a thermal power station, the chemical energy of coal is changed into heat energy which is further changed into electrical energy with the help of an electric generator.

97. Name the transformation of energy involved in the following cases :
(a) When a body is thrown upwards.
(b) When a body falls from the top of a hill.
(c) When coal burns.
(d) When a gas burns.
(e) When water falls from a height.

Ans :

(a) Kinetic energy into potential energy.
(b) Potential energy into kinetic energy.
(c) Chemical energy into heat energy.
(d) Chemical energy into heat energy.
(e) Potential energy into kinetic energy.

98. What are the factors on which the work done depends?

Ans :

The work done by a force depends upon :
(i) The magnitude of the force.
(ii) The magnitude of the displacement.
(iii) The angle between force and displacement.

99. How are kinetic energy and momentum related?

Ans :

Kinetic energy is given by the relation $K = \frac{1}{2}mv^2$. Multiplying and dividing the right hand side of the equation by m, we have

$$K = \frac{m^2v^2}{2m} = \frac{p^2}{2m}$$

(mv = p is momentum of a body)

Therefore, $p = \sqrt{2mK}$

100. What is the work done by a coolie walking on a horizontal platform with a load on his head?

Ans :

In order to balance the load on his head, the coolie

applies a force on it in the upward direction, equal to its weight. His displacement is along the horizontal direction. Thus, the angle between force F and displacement is 90°. Therefore, work done

$$W = Fs \cos \theta = Fs \cos 90° = 0.$$

101. We wind our watch once a day, what happens to the energy?

Ans :

When we wind our watch, we wind the spring inside the watch. As a result, energy is stored in the spring in the form of elastic potential energy. This elastic potential energy is used to make the watch work the whole day.

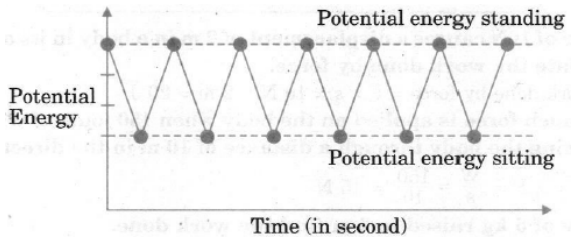
102. Distinguish between work, energy and power. State the SI units for each of these quantities.

Ans :

Work : It is defined as the product of force applied and the distance moved by the body on the application of the force. In SI unit it is measured in joule.
Energy : It is defined as the capacity of a body to do work. In SI unit it is measured in joule.
Power : It is defined as the rate of doing work. It measures how fast or slow the work is done. In SI unit it is measured in watt unit.

103. A girl sits and stands repeatedly for 5 minutes. Draw a graph to show variation of potential energy with time.

Ans :



104. Define 1 J of work.

Ans :

Work done = Force x Displacement
Force, F = 1 N and displacement, s = 1 m, then the work done by the force will be 1 Nm or 1 J. Thus, 1 J is the amount of work done on an object when a force of 1 N displaces it by 1 m along the line of action of the force.

105. A light and a heavy body have the same momentum. Which one will have greater kinetic energy?

Ans :

As $K = \frac{p^2}{2m}$ and p is same for both. Hence, $K \propto \frac{1}{m}$
Thus, the lighter body has more kinetic energy than the heavier body.

106. (i) What is a closed system?
(ii) State the law of conservation of energy.

Ans :

(i) A system that does not interact with another is a closed system. Energy in a closed system is neither taken out of it nor taken in from outside. However, energy transformation may occur inside a closed system.
(ii) The law of conservation of energy states that "the energy can neither be created nor destroyed, but can be transformed from one form to another. In other words, the total energy of a closed system remains constant. Therefore, whenever one from of energy disappear, an equivalent amount of another form appears.

107. Name the form of energy associated in each case :
(i) A flying bird.
(ii) A man climbing the stairs.
(iii) A compressed watch spring.
(iv) A fast moving object.

Ans :

(i) Mechanical energy
(ii) Mechanical energy
(iii) Potential energy
(iv) Kinetic energy

108. Name the various forms of energy.

Ans :

The various forms of energy are :
(i) Potential energy
(ii) Kinetic energy
(iii) Mechanical energy
(iv) Heat energy
(v) Chemical energy
(vi) Electrical energy
(vii) Light energy.

109. (a) What is meant by potential energy? Is potential energy vector or scalar quantity?
(b) Give one example of a body having potential energy.

Ans :

(a) The energy possessed by a body by virtue of its position or configuration. It is a scalar quantity.
(b) Stretched string of a bow.

110. When is the work done by a force said to be negative? Give one situation in which one of the forces acting on the object is doing positive work and the other is doing negative work.

Ans :

We know that work done W = Fs cos θ, where θ is the angle between F and S. Clearly, W will be –ve, if θ is between 90° and 180° because then cos θ will be –ve. Consider the case of a body falling under gravity. The body experiences an upward frictional force and downward force due to gravity. Since, the body is moving downwards, the work done by force to gravity will be +ve but that is against the upward thrust will be –ve.

111. An object of mass when raised to height h possess a potential energy of 1200 J. Find the new potential energy :

(a) if the same object is raised to height $\frac{h}{4}$.

(b) if the same object is raised to height 4h.

Ans :

PE = 1200 joules

(a) New PE = $\frac{1}{4}$ old PE = $\frac{1}{4} \times 1200 = 300$ joules

(b) New PE = 4 × old PE = 4 × 1200 = 4800 joules

112. Define 1 watt of power. A lamp consumes 1000 J of electrical energy in 10 s. Calculate its power.

Ans :

The power of an agent is said to be one watt if it does one joule of work in one second.

(a) Given W = 1000 J, t = 10 s, P = ?

(b) Using the expression,

$$P = \frac{W}{t},$$

we have $P = \frac{1000}{10} = 100$ W

113. Explain that the flying bird has; potential and kinetic energy and give their expressions.

Ans :

The potential energy of the bird while flying in the sky is with respect to the Earth. The KE is due to its velocity with which it is flying.

$$PE = mgh \text{ and } KE = \frac{1}{2} mv^2$$

114. (a) An arrow moves forward when released from a stretched bow. Explain the transformation of energy in the process.

(b) A boy of mass 50 kg climbs up a vertical height of 100 m. Calculate the amount of potential energy he gains.

Ans :

(a) When the bow is stretched it stores potential energy. When the arrow is released the potential energy stored in the bow gets transformed into the kinetic energy of the arrow.

(b) Given m = 50 kg, h = 100 m,

g = 10 ms^{-1}, PE = ?

PE = mgh = 50 × 10 × 100 = 5000 J

115. Define : (a) power (b) work done (c) kinetic energy. Give SI unit of each.

Ans :

(a) The rate of doing work is called power. Its SI unit is watt.

(b) Work is the product of force and displacement. Its SI unit is joule.

(c) It is the energy possessed by a body by virtue of its motion. Its SI unit is joule.

116. Define power. Write commercial unit and SI unit of electrical energy. An electrical geyser of 1.5 kW works for 2 hours. Find the electrical energy units consumed in a day.

Ans :

Power is defined as the rate of doing work. SI unit is joule and kWh is the commercial unit of electrical energy.

Given, P = 1.5 kW,

t = 2 hours,

E = P × t = 1.5 × 2 = 3 kWh

117. The masses of scooter and bike are in the ratio of 2 : 3 but moving with same speed of 108 km h^{-1}. Compute the ratio of their kinetic energy.

Ans :

The energy possessed by a body by virtue of its motion.

Given, $\frac{m_1}{m_2}$, $\frac{2}{3}$, the ratio of KE is equal to the ratio of their masses if they have the same velocity, therefore, ratio of their KE is also 2 : 3.

NUMERICAL QUESTIONS

118. A force of 10N causes a displacement of 2 m in a body in its own direction. Calculate the work done by force.

Ans :

The work done by force = F × s = 10 N × 2 m = 20 J

119. How much force is applied on the body when 150 joule of work is done in displacing the body through a distance of 10 m in the direction of force?

Ans :

$$W = F \times s$$

$$F = \frac{W}{s}$$

$$= \frac{150}{10} = 15N$$

120. A body of 5 kg raised to 2 m find the work done.

Ans :

The work done to raise a body

= PE

= mgh

= 5 kg × 9.8 × 2 = 98 joule

121. A work of 4900 J is done on load of mass 50 kg to lift it to a certain height. Calculate the height through which the load is lifted.

Ans :

Work done on road to lift = mgh

4900 = 50 × 9.8 h

$$h = 10 \text{ m}$$

122. An engine work 54,000 J work by exerting a force of 6000 N on it. What is the displacement of the force?

Ans :

$$S = = \frac{W}{F} = \frac{54000 \text{ J}}{6000 \text{ N}} = 9 \text{ m}$$

123. A body of mass 2 kg is moving with a speed of 20 m/s. Find the kinetic energy.

Ans :

$$KE = 0.5 \text{ mv}^2$$
$$= 0.5 \times 2 \times 20 \times 20 = 400 \text{ J}$$

124. A moving body of 30 kg has 60 J of KE. Calculate the speed.

Ans :

$$KE = 0.5 \text{ mv}^2$$
$$60 = 0.5 \times 30 \times v^2$$
$$60 = 15 \text{ v}^2$$
$$v = 2 \text{ m/s}$$

125. A hammer of mass 1 kg falls freely from a height of 2 m. Calculate (I) The velocity and (II) The kinetic energy of the hammer just before it touches the ground. Does the velocity of hammer depend on the mass of hammer?

Ans :

$$PE = mgh = 1 \times 9.8 \times 2 = 19.6 \text{ J}$$
$$PE = KE = 0.5 \text{ mv}^2$$
$$19.6 = 0.5 \times 1 \times v^2$$
$$39.2 = v^2$$
$$v = 6.29 \text{ m/s}$$

No, velocity of hammer does not depend on the mass of the hammer as $v = u + at$

126. Calculate the change that should be affected in the velocity of a body to maintain the same KE, if mass of the body is increased to 4 times.

Ans :

$$\text{Original KE} = \tfrac{1}{2}\text{mv}_1^{\,2}$$

Now, if mass if increase 4 times then,

$$\text{New KE} = 4 \times \tfrac{1}{2}\text{mv}_2^{\,2}$$
$$\tfrac{1}{2}\text{mv}_1^{\,2} = 4 \times \tfrac{1}{2}\text{mv}_2^{\,2}$$
$$v_1^{\,2} = 4v_2^{\,2}$$
$$v_2 = \frac{v_1}{2}$$

Hence, new velocity will be bay the original velocity.

127. A machine does 192 J of work in 24 sec. What is the power of the machine?

Ans :

$$P = \frac{W}{t} = \frac{192 \text{ J}}{24 \text{ sec}} = 8 \text{ W}$$

128. A weight of 50 kg runs up a hill rising himself vertically 10 m in 20 sec. Calculate power. (Given g = 9.8 ms^{-1})

Ans :

$$P = \frac{W}{t} = \frac{mgh}{t}$$
$$= \frac{(50 \times 9.8 \times 10)}{20} = 245 \text{ W}$$

129. A rickshaw puller pulls the rickshaw by applying a force of 100 N. If the rickshaw moves with constant velocity of 36 kmh^{-1}. Find the power of rickshaw puller.

Ans :

$$\text{Force} = 100 \text{ N}$$
$$\text{Velocity} = 36 \text{ km/h}$$
$$= \frac{36 \times 5}{18} = 10 \text{ m/s}$$
$$\text{Power} = \text{Force} \times \text{Velocity}$$
$$\text{Power} = 100 \times 10 = 1000 \text{ Watt}$$

Therefore, power of rickshaw puller = 1000 Watt

130. An athlete weighing 60 kg runs up a staircase having 10 steps each of 1 m in 30 sec. Calculate power (g = 9.8ms^{-1}).

Ans :

$$h = 10 \times 1\text{m} = 10 \text{ m}$$
$$\text{Work done} = \text{potential energy}$$
$$= \text{mgh}$$
$$= 60 \times 9.8 \times 10$$
$$= 5880 \text{ J}$$
$$\text{Power} = \frac{W}{t} = \frac{5880}{30} = 196 \text{ W}$$

131. The heart does 1.5 J of work in each heartbeat. How many times per minute does it beat if its power is 2 watt?

Ans :

$$\text{Total work} = P \times t = 120 \text{ J},$$

Number times heartbeat in 1 min.

$$= \frac{\text{Total work done}}{\text{Work done in each beat}}$$
$$= \frac{120}{1.5} = 80 \text{ times}$$

132. Calculate the time taken by 60 W bulb to consume 3000 J of energy.

Ans :

$$\text{Power} = 60 \text{ W and Energy consumed} = 3000 \text{ J}$$

We know that

$$\text{Power} = \frac{\text{Energy}}{\text{Time Taken}}$$
$$\text{Time Taken} = \frac{\text{Energy Consumed}}{\text{Power}}$$
$$= \frac{3000}{60} = 50 \text{ sec}$$

133. A horse exert a force of 200N to pull the cart. If the horse cart system moves with velocity 36 kmh^{-1} on the level road, then find the power of horse in term of horse power (1 HP = 746 W).

Ans :

$$\text{Velocity} = 36\ kmh^{-1} = 10\ m/s$$

$$W = F \times s = 200 \times 10 = 2000J$$

$$P = \frac{W}{t} = \frac{2000\ J}{1\ sec} = 2000\ W$$

$$746\ W = 1\ HP$$

So, $$2000\ W = \frac{2000}{746} = 2.68\ HP$$

134. An electric kettle of 500W is used to heat water everyday for 2 hours. Calculate the number of unit of electrical energy consumed by it in 10 days.

Ans :

$$E = Pt = 500\ W \times 10 \times 2h$$
$$= 10000\ Wh$$
$$= 10\ kWh = 10\ unit$$

135. Calculate the cost of using a 2 kWh immersion rod for heating water in a house for one hour each day for 60 days if the rate is 1.50 per unit kWh.

Ans :

$$E = Pt = 2\ kW \times 60 \times 1\ h$$
$$= 120\ kWh = 120\ unit$$

The cost of using a 2 kWh immersion rod for heating water = 120 × 1.5 = Rs 180

136. In an experiment to measure his power, a student records the time taken by him in running up a flight of steps on a staircase.

Ans :

Use the following data to calculate the power of the student :

Number of steps = 28,

Height of each step = 20 cm,

Time taken = 5.4 s,

Mass of student = 55 kg,

Acceleration due to gravity = 9.8 ms^{-2}

$$\text{Power} = \frac{W}{t} = \frac{mgh}{t}$$
$$= \frac{55 \times 9.8 \times (28 \times 0.20)}{5.4}$$
$$= 559\ J$$

137. A bullet of mass 15 g has a speed of 400 m/s. What is its kinetic energy? The bullet strikes a thick target and is brought to rest in 2 cm, calculate the average net force acting on the bullet. What happens to kinetic energy originally in the bullet?

Ans :

$$K.E. = \tfrac{1}{2}mv^2$$
$$= 0.5 \times 0.015\ kg \times (400 \times 400)$$
$$= 1200\ J.$$

Work done = Change in K.E.

As final velocity = 0

So, change in KE = $K_f - K_i$ = 1200 J

Therefore, $F \times d = 1200$

(where F is the average force.)

$$F = \frac{1200}{2 \times 10^{-2}} = 6 \times 10^4 N.$$

The kinetic energy is eventually converted to heat energy.

138. The power of a heart which beats 72 times in a minute is 1.2 kW. Calculate the work done by heart for each beat. (1 kJ)

Ans :

$$P = 1200\ W \text{ and } t = 60\ s$$

$$W = P \times t = 1200 \times 60 = 72000J$$

In 72 times heartbeats 72000 J energy used

$$\text{In 1 beat} = = \frac{72000}{72} = 1000J$$

Work done by the heart in every beat is 1 KJ.

139. When loading a truck, a man lifts boxes of 100 N each through a height of 1.5 m.

(a) How much work does he do in lifting one box?

(b) How much energy is transferred when one box is lifted?

(c) If the man lifts 4 boxes per minute, at what power is he working? (g = 10 m s^{-2})

Ans :

(a) Work done in lifting one box = F × d = 100 × 1.5 = 150 J.

(b) W = E = 150 J.

(c) $\text{Power} = \frac{\text{Work done}}{\text{Time}} = \frac{150 \times 4}{60} = 10\ W$

140. (a) Define average power.

(b) A lamp consumes 1000 J of electrical energy in 10 s. What is its power?

(c) Give the commercial unit of energy in joules.

Ans :

(a) Average power is defined as the ratio of total energy consumed to the total time taken.

(b) $P = \frac{E}{t} = \frac{1000}{10} = 100\ W$

(c) 1 kWh = 3.6×10^6 J

141. Calculate the electricity bill amount for a month of 31 days, if the following devices are used as specified.

(a) 3 bulbs of 40 W for 6 hours.

(b) 4 tubelights of 50 W for 8 hours,

(c) A TV of 120 W for 6 hours.

The rate of electricity is Rs 2.50 per unit.

Ans :

$$E_l = P \times t = 0.04 \times 6 \times 3$$
$$= 0.72\ kWh$$
$$E_2 = P \times t = 0.05 \times 8 \times 4$$
$$= 1.60\ kWh$$

$$E_3 = 0.12 \times 6 = 0.72 \text{ kWh}$$

$$\text{Total E} = 0.72 + 1.6 + 0.72 = 3.04 \text{ kWh}$$

$$\text{Cost in 31 days} = \text{rate} \times \text{E}$$

$$= 3.04 \times 2.50 \times 31 = \text{Rs } 235.60$$

142.(a) What is meant by mechanical energy? State its two forms. State the law of conservation of energy. Give an example in which we observe a continuous change of one form of energy into another and vice-versa.

(b) Calculate the amount of work required to stop a car of 1000 kg moving with a speed of 72 km/h.

Ans :

(a) It is the sum of KE and PE of an object. It states that energy can neither be created nor be destroyed. We observe a continuous change in energy in a simple pendulum. At the mean position, the energy is totally kinetic while at the extreme position it is totally potential. As the pendulum oscillates its energy continuously changes between kinetic and potential.

(b) Given m = 1000 kg, u = 72 kmh^{-1} = 20 ms-1, v = 0

Work done = change in kinetic energy

$$= \frac{1}{2}m(v^2 - u^2) = \frac{1}{2} \times 1000 \times (0^2 - 20^2)$$

$$= -200000 \text{ J} = -2 \times 10^5 \text{ J}$$

143.(a) State the law of conservation of energy.

(b) What is the work done to increase the velocity of a car from 36 km h^{-1} to 72 kmh^{-1} if the mass of the car is 1500 kg? Does the work done by the force have a negative or a positive magnitude?

(c) Where does an oscillating pendulum have maximum PE and RE?

Ans :

(a) It states that energy can neither be created nor be destroyed.

(b) Given, m = 1500 kg, u = 36 kmh^{-1} = 10 ms^{-1}, v = 72 k mh^{-1} = 20 ms^{-1}, W = ?

Work done = change in kinetic energy

$$= -2\text{m}\ (v_2 - u_2)$$

$$= -2 \times 1500 \times (20^2 - 10^2)$$

$$= 225000 \text{ J}$$

The work done is positive.

(c) It has maximum potential energy at its extreme position and maximum kinetic energy at the mean position.

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Science IX

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